

1 Docket No. 6016.37002

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3  
4 SPECIFICATION

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7  
8 TO ALL WHOM IT MAY CONCERN

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11 BE IT KNOWN that I, Johnnie E. Floyd, of the United  
12 States, residing in the State of Texas, have invented new and  
13 useful improvements in a

14  
15 LENS ARRANGEMENT WITH FLUID CELL AND  
16 PRESCRIPTIVE ELEMENT

17  
18 of which the following is a specification:  
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1 LENS ARRANGEMENT WITH FLUID CELL AND  
2 PRESCRIPTIVE ELEMENT  
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5 SPECIFICATION  
6

7 Field of the Invention

8 The present invention relates to lens arrangements used to provide  
9 correction to eyes.  
10

11 Background of the Invention

12 Many people have trouble seeing clearly as they get older. The  
13 common solution is to wear corrective lenses, whether the lenses are  
14 supported on the nose by a frame or else in contact with the eyes.

15 Corrective lenses work by providing the proper focus of the image for  
16 the eye. Much of the eyewear in use has only a single lens in front of the  
17 eye. Many people require two or more lenses. Hence the use of bifocals and  
18 trifocals. A pair of bifocals allows the user to look relatively far away (for  
19 example to drive) and also allows the user to look fairly close (for example  
20 to read). Thus, bifocals provide two focal lengths for the wearer, with each  
21 lens providing the respective focal length.

22 The problem with conventional eyewear is that the lens is fixed at its  
23 respective focal length. Some people do not wear bifocals, so they have two  
24 pairs of eyeglasses. One pair is for up close reading and the other pair is for  
25 looking relatively far away.

Also, the amount of correction needed typically changes throughout one's life. This change can be either gradual or more dramatic. For example, diabetics may find that their eyes change focal length throughout each day, due to the fluctuation of blood sugar. In the morning, their eyes are at one focal length while in the afternoon, the focal length is changed.

Frequent updating of a corrective lens can be expensive.

### Summary of the Invention

It is an object of the present invention to provide a lens that allows for the corrective power to be easily changed, without the need to replace the entire lens.

It is another object of the present invention to provide a lens having a fluid cell for adjustment of corrective power, which lens can be mounted into conventional eyewear frames.

It is another object of the present invention to provide a lens having a fluid cell, which lens allows the replacement or adjustment of a corrective element.

It is another object of the present invention to provide a lens having a fluid cell, which fluid cell produces a minimum corrective power when fluid pressure is lost.

The present invention provides a lens arrangement for use in applying a corrective power. The lens arrangement includes a fluid lens cell formed by first and second lens elements. The chamber is sealed by a seal and contains a transparent fluid. The first and second lens elements are made of transparent material. One of the first or second lens elements is flexible. A

1 passage is coupled to the fluid lens cell so as to allow communication with  
2 the chamber. The passage provides for the flow of the fluid therethrough so  
3 that the volume of the chamber can be changed. There is a rigid third lens  
4 element having first and second surfaces that are shaped to provide optical  
5 correction. The third lens element is removably coupled to an exterior of the  
6 fluid cell so as to be adjacent to the fluid cell and optically aligned with the  
7 fluid cell.

8 In accordance with one aspect of the present invention, the fluid cell is  
9 capable of providing a null correction. In accordance with another aspect of  
10 the present invention, the fluid cell provides a null correction when the  
11 flexible first or second lens element is unflexed.

12 In accordance with another aspect of the invention, at least one of the  
13 first or second lens elements comprises a negative lens. This provides a fail  
14 safe mode should the fluid be drained from the cell so that the wearer will  
15 have far vision.

16 In accordance with still another aspect of the present invention, the  
17 flexible one of the first or second lens elements comprises a membrane. The  
18 membrane has an edge portion and a center portion, with the edge portion  
19 being pivotally coupled to an annular member between the first and second  
20 lens elements, wherein the center portion of the membrane can flex.

21 In accordance with another aspect of the present invention, the  
22 flexible one of the first or second lens elements comprises a membrane. The  
23 third lens element is adjacent to the membrane, there being a space between  
24 the third lens element and the membrane to allow the membrane to flex.

1 In accordance with still another aspect of the present invention, one of  
2 the first or second surfaces of the third lens element is spherical and the  
3 other of the first or second surfaces is cylindrical.

4 In accordance with still another aspect of the present invention, one of  
5 the first or second surfaces of the third lens element is cylindrical, and has a  
6 cylindrical axis. The third lens element is rotatable relative to the fluid cell  
7 so as to vary the cylindrical axis orientation.

8 In accordance with still another aspect of the present invention, the  
9 first and second lens elements each have two surfaces, with at least one of  
10 the surfaces of the first, second or third lens element being coated, shaded or  
11 polarized.

12 In accordance with another aspect of the present invention, the  
13 flexible one of the first or second lens elements includes a membrane. The  
14 membrane has two flat surfaces.

15 In accordance with another aspect of the present invention, the  
16 flexible one of the first or second lens elements comprises a membrane, the  
17 membrane having two surfaces, with one of the membrane surfaces being  
18 curved.

19 In accordance with still another aspect of the present invention, the  
20 third lens element is coupled to the fluid cell independently of the fluid lens  
21 seal, wherein the third lens element can be removed from the lens  
22 arrangement without disturbing the seal.

23 In accordance with still another aspect of the present invention, the  
24 third lens element is rotatably coupled to the fluid cell.

1 In accordance with still another aspect of the present invention, the  
2 third lens element includes a prescription lens. The third lens element is  
3 coupled to the fluid cell by way of an adapter which is structured and  
4 arranged for receiving the third lens element.

5 The present invention provides a lens arrangement for use in applying  
6 a corrective power. The lens arrangement includes a base, a flexible  
7 membrane, and a corrective lens element. The base has first and second  
8 surfaces. The flexible membrane has third and fourth surfaces, with the  
9 second surface of the base and the third surface of the membrane being  
10 adjacent to each other and forming a chamber therebetween. The membrane  
11 has an edge portion and a center portion. The edge portion being coupled to  
12 the base wherein the center portion can flex. The chamber is sealed and  
13 contains a transparent fluid. The base and the membrane are made of  
14 transparent materials and form a fluid cell. A passage communicates  
15 between the chamber and the exterior of the fluid cell so as to allow the  
16 amount of fluid within the chamber to be changed. The corrective lens  
17 element has fifth and sixth surfaces that are shaped to provide optical  
18 correction. The corrective lens element is removably coupled to the base so  
19 as to be adjacent to the fluid cell.

20 In accordance with one aspect of the present invention, the corrective  
21 lens element is rotatably coupled to the base.

22 In accordance with another aspect of the present invention, one of the  
23 fifth or sixth surfaces of the corrective lens element is spherical and the other  
24 of the fifth or sixth surfaces is cylindrical.

1 In accordance with still another aspect of the present invention, the  
2 corrective lens element is coupled to the base by way of a ring member. The  
3 membrane edge portion is pivotally coupled between the base and the ring  
4 member.

5 In accordance with another aspect of the present invention, the  
6 corrective lens element is adjacent to the membrane.

7 In accordance with still another aspect of the present invention, one of  
8 the third or fourth surfaces of the membrane is spherical.

9 In accordance with still another aspect of the present invention, the  
10 first and second surfaces of the base, the fluid and the third and fourth  
11 surfaces of the membrane form a null correction when the membrane is in an  
12 unflexed position.

13 In accordance with still another aspect of the present invention, the  
14 base comprises a negative lens. This provides a fail safe mode should the  
15 fluid cell lose fluid, so that the wearer will have far vision.

16 In accordance with still another aspect of the present invention, the  
17 base is mounted into an eyewear frame.

18 The present invention also provides an arrangement of lenses  
19 comprising a first lens and a second lens. Each of the first and second lenses  
20 comprise a fluid lens cell having a chamber formed by first and second lens  
21 elements. The chamber is sealed by a seal and contains a transparent fluid.  
22 The first and second lens elements are made of a transparent material. One  
23 of the first or second lens elements is flexible. Each of the first and second  
24 lenses comprise a passage coupled to the fluid lens cell so as to allow  
25 communication with the chamber. The passage provides for flow of the

1 fluid therethrough so that the volume of the chamber can be changed. The  
2 passage communicates with a fluid pump and the pump is controlled by a  
3 controller. One of the first lens controller or the second lens controller  
4 selectively controls one or both of the first lens pump and the second lens  
5 pump.

6 In accordance with another aspect of the present invention, each of the  
7 first and second lenses comprise a rigid third lens element having first and  
8 second surfaces that are shaped to provide optical correction. The third lens  
9 element is removably coupled to an exterior wall of the respective fluid cell  
10 so as to be adjacent to the fluid cell and optically aligned with the fluid cell.

#### 11 12 Brief Description of the Drawings

13 Fig. 1 is a cross-sectional view of the lens arrangement of the present  
14 invention, in accordance with a preferred embodiment.

15 Fig. 2 is a cross-sectional detail view of the outer periphery of the lens  
16 arrangement of Fig. 1.

17 Fig. 3 is a cross-sectional detail view of the lens arrangement, in  
18 accordance with another embodiment.

19 Fig. 4 is a cross-sectional detail view of the lens arrangement, in  
20 accordance with still another embodiment.

21 Fig. 5 is a cross-sectional detail view of the lens arrangement, in  
22 accordance with still another embodiment.

23 Fig. 6 is a cross-sectional detail view of the lens arrangement, in  
24 accordance with still another embodiment.



Fig. 7 is a cross-sectional view of a membrane, in accordance with another embodiment.

Fig. 8 is a schematic block diagram showing a pump and controller arrangement for a pair of eyeglasses.

Fig. 9 is a cross-sectional view of the lens arrangement, in accordance with a preferred embodiment.

#### Description of the Preferred Embodiments

In Figs. 1 and 2, there are shown cross-sectional views of the lens arrangement 11 of the present invention. The lens arrangement can be used in conventional eyewear such as a frame 13. The lens arrangement can be used in a variety of other devices as well, such as goggles, shields, instruments, etc. The lens arrangement 11 has a corrective lens element 17 in the form of a prescription lens. The prescription lens 17 provides a fixed corrective power to the user.

The corrective power of the lens 17 can be altered by a fluid cell 15 which is located adjacent to the lens 17. The fluid cell has a flexible membrane 21 which changes curvature depending on the amount of fluid within the fluid cell. The fluid 23 inside of the fluid cell 15 acts as a lens element, with one of its boundaries being the adjustable membrane 21. The membrane 21 can flex either toward the prescription lens 17 or away from the prescription lens. In a sense, the fluid cell can either add or subtract power to and from the prescription lens 17. The addition or subtraction of power is to the combination lens arrangement; the lens 17 itself is unmodified.

1 In an eyeglass frame 13, there are two lens arrangements 11 provided,  
2 one for each eye. Each lens arrangement 11 can be focused independently  
3 of the other.

4 In addition, the prescription lens 17 is removably coupled to the fluid  
5 cell 15. Thus, the prescription lens can be changed and replaced with  
6 another prescription lens having a different corrective power. Furthermore,  
7 the prescription lens can be rotated relative to the fluid cell and to the  
8 eyewear frame 13. This is useful if the prescription lens has a cylindrical  
9 surface, wherein the axis of the cylinder can be adjusted to correct an  
10 astigmatism. Furtherstill, the prescription lens 17 can be changed or rotated  
11 without affecting the fluid cell. This is because the fluid does not wet the  
12 prescription lens. Instead, the fluid cell is separate from the prescription  
13 lens.

14 The lens arrangement 11 will now be described in more detail. The  
15 lens arrangement 11 has the fluid cell 15, the prescription lens 17, a pump  
16 25L, 25R (see Fig. 8) and a controller 27L, 27R for the pump.

17 The lens arrangement uses many of the features of the lens cell of  
18 Floyd, U.S. Patent No. 5,684,637, the entire disclosure of which is  
19 incorporated herein. For example, in the '637 patent, there is disclosed  
20 structure for supporting the edge of a flexible membrane in a fluid cell. This  
21 support structure is used herein.

22 Referring back to Figs. 1 and 2, the fluid cell 15 includes a base 19 and  
23 a membrane 21. The base 19 has a center portion 29 and an edge portion 31.  
24 The base 19 has a first surface 33 and a second surface 35. The base 19 also  
25 has a central axis 37 that extends through the center portion 29 and the first

1 and second surfaces 33, 35. The first surface 33 forms an exterior surface of  
2 the overall lens arrangement 11.

3 The edge portion 31 of the base 19 can be ground and beveled 39 as  
4 shown so as to mount the base into an eyewear frame 13. The frame 13 is  
5 conventional and commercially available. Consequently, the circumference  
6 of the base 19 may be noncircular so as to fit properly within the frame.

7 Referring to Fig. 2, the base 19 has a lip 41 that extends in an axial  
8 direction from the side of the base with the second surface 35. The lip 41 is  
9 located around the edge portion 31 of the base and is ring shaped, as it  
10 extends around the circumference of the base. The lip 41 can be circular, or  
11 it can approximate the shape of the edge portion 31 (for example oval,  
12 irregular, etc.).

13 Located interiorly of the lip 41 is a projection 43. The projection 43 is  
14 also ring shaped. In cross-section, as shown in Fig. 2, the projection 43 is  
15 rounded. Alternatively, the projection can be somewhat pointed. The  
16 projection is used to reduce the bending moment on the edge portion of the  
17 membrane 21, as discussed in more detail in Floyd, U.S. Patent No.  
18 5,684,637. Grooves or slots 45 are formed in the projection 43, in order to  
19 allow the fluid 23 to traverse therethrough. Thus, the contact between the  
20 projection 43 and the membrane 21 need not be fluid tight. The grooves 45  
21 are at various locations in the ring shaped projection 43.

22 The base 19 is made of a transparent material, such as plastic or glass,  
23 that is suitable for use in eyewear. The base can be molded, wherein the first  
24 and second surfaces 33, 35 can be polished to provide optical clarity.

1 Alternatively, the base can be machined, or a combination of molded and  
2 machined.

3 The membrane 21 is flexible and has a center portion 47 and an edge  
4 portion 49. The circumference of the membrane 21 is large enough so that  
5 the membrane edge portion 49 contacts the base projection 43 and even  
6 extends slightly beyond. Thus, the membrane edge portion contacts the  
7 projection 43 all around its circumference (with the exception of the grooves  
8 45 of the projection).

9 The membrane 21 has a third surface 51 and a fourth surface 53. The  
10 third surface 51 of the membrane 21 faces the second surface 35 of the base.  
11 A chamber 55 is formed between the second and third surfaces 35, 51, which  
12 chamber is filled with the fluid 23.

13 The membrane third and fourth surfaces 51, 53 can be either flat  
14 (plano) or curved. For example, Figs. 1 and 2 show the membrane third and  
15 fourth surfaces 51, 53 as being flat. Fig. 7 shows another membrane 21A in  
16 a cross-section, which has a curved third surface 51A and a flat fourth  
17 surface 53A. Either the third or the fourth surface, or both, could be curved.  
18 The curvature could be spherical, which is generally accepted in the optical  
19 industry. Alternatively, the curvature could approximate spherical (for  
20 example by a parabolic curve) or some other shape. The membrane 21A of  
21 Fig. 7 has a curvature such that the center portion 47A is thicker in cross-  
22 section than the edge portion 49A. By controlling the membrane thickness  
23 at selected distances from a membrane centerline, the inherent membrane  
24 refraction, combined with the resulting membrane deflections, can form a  
25 variety of useful fluid lenses.

1 The membrane 21, 21A is made of a transparent material such as  
2 plastic. The membrane can be made by many processes (such as molding)  
3 and from many materials, as long as the membrane is transparent when used  
4 in the refractive mode, and is flexible, generally having an elastic modulus  
5 less than  $1.5 * 10^6$  psi.

6 Referring again to Fig. 2, there is also a ring member 57 that is used to  
7 secure the membrane 21 and provide a seal for the fluid 23. The ring  
8 member 57 is ring shaped, generally conforming to the shape of the base lip  
9 41. The ring member 57 is coupled to the base lip 41. In Fig. 1, the coupling  
10 is accomplished with threads 59. In this embodiment, the threaded surfaces  
11 of the ring member 57 and the base lip 41 are circular.

12 A seal 61 is provided on the ring member 57 to contact the membrane  
13 edge portion 49, all around the circumference of the membrane 21. The seal  
14 61 is round in cross-section before assembly. After assembly into the base  
15 19, the seal 61 flattens against the membrane 21, as shown in Fig. 2.

16 When the ring member 57 is threaded into the base 19, the membrane  
17 edge portion 49 is captured between the seal 61 and the projection 43. The  
18 center portion 47 of the membrane is free to flex. In addition, the edge  
19 portion 49 is also free to flex with the center portion 47. The seal 61 and the  
20 projection 43 minimize any distortion at the edge portion 49 of the  
21 membrane 21, which distortion usually arises when the membrane edges are  
22 fixed and unmovable. With the fluid cell of Fig. 1, the edge portion pivots  
23 when the center portion of the membrane flexes. The seal 61 also prevents  
24 the fluid from leaking out of the fluid cell, as it provides a fluid tight seal  
25 against the fourth surface 53.

1 The ring member 57 is equipped with a groove 63 and an o-ring 65  
2 therein to completely seal the fluid cell. The o-ring 65 can be positioned  
3 such that the threads 59 are wetted by the fluid (Figs. 1 and 2) or the threads  
4 59A are kept dry (see Fig. 3).

5 The fluid 23 that is used inside of the fluid cell is transparent and has  
6 a viscosity to allow for ease of movement in and out of the cell. The fluid  
7 could be water. The water can have an amount of alcohol added to lower its  
8 freezing point. Other fluids that could be used include mineral oil, glycerin,  
9 silicon, etc.

10 The fluid is moved in and out of the fluid cell by way of passages 67,  
11 69 (see Fig. 1). In the preferred embodiment, two passages are provided.  
12 The fluid enters the cell via an inlet passage 67 and exits through the other,  
13 or outlet, passage 69. The provision of two passages simplifies the removal  
14 of any gas that might enter the fluid cell, which fluid cell contains liquid as  
15 the fluid of choice. The gas can be removed through the outlet passage 69.

16 The passages 67, 69 penetrate the base lip 41 and are preferably  
17 spaced apart from each other. The passages need not be spaced 180 degrees  
18 apart. Each passage 67, 69 can include an opening 71 in the base lip 41,  
19 which opening receives a tube 73 (see Fig. 2, which shows the inlet passage  
20 67 in detail). The tube 73 extends from the fluid cell 15 to the pump. Each  
21 passage communicates with the fluid cell chamber 55 by a circumferential  
22 antechamber 75, which is located radially outward of the seal 61 and the  
23 projection 43. The antechamber 75, which extends around the membrane,  
24 communicates with the fluid cell chamber 55 by the grooves 45. Thus, fluid  
25 23 flows through the tube 73, the opening 71, into the antechamber 75, and

1 once in the antechamber, flows around a portion of the circumference of the  
2 projection 43 and through one or more grooves 45 into the fluid chamber 55.  
3 To exit the chamber, the fluid follows a similar path via the outlet passage  
4 69.

5 The tubes 23 are formed by respective fittings 70. Flexible tubing 22  
6 is attached to each fitting and conveys fluid to and from the pump 25.

7 A one way check valve 77 (see Fig. 1) can be provided in each  
8 passage 67, 69. Each check valve comprises a ball 79 that is contained  
9 inside of the opening 71. A spring 83 urges the ball 79 into a valve seat 85.  
10 The check valves in the passages 67, 69 are similar to one another, except  
11 that ball and spring positions are interchanged. The inlet passage 67 has a  
12 check valve arranged to allow fluid to flow into the antechamber 75, while  
13 the outlet passage 69 has a check valve arranged to allow fluid to flow out of  
14 the antechamber into the tube. The check valves can be contained either  
15 within the base 19 or closer to the pump.

16 The prescription lens 17 has fifth and sixth surfaces 87, 79. The fifth  
17 surface 87 is adjacent to the membrane fourth surface 53. The fifth and sixth  
18 surfaces 87, 89 are formed to provide the necessary corrective power to the  
19 wearer. Most corrective lens provide a spherical surface. Either one of, or  
20 both of, the fifth or sixth surfaces can be spherical. If the lens is to correct  
21 for astigmatism, then the other of the fifth or sixth surfaces is cylindrical, in  
22 accordance with modern conventional lens design. Because it is industry  
23 practice to provide that the surface closer to the wearer's eye is cylindrical,  
24 while the other surface is spherical, that same practice is followed in the  
25 preferred embodiment, such that the fifth surface 87 is spherical, while the

sixth surface 89 is cylindrical. In the optical industry, a spherical surface need not be a true sphere. For example, a surface can be aspheric, with more curvature in the middle of the lens and less curvature at the edges. Also, a cylindrical surface could be toric. As used herein, spherical and cylindrical encompass such other approximate shapes.

The cylindrical surface 89 has a central axis. The portion of the cylindrical surface on one side of the axis is symmetrical with the portion of the cylindrical surface on the other side of the axis.

The fifth and sixth surfaces 87, 89 can be wrapped around a base curve, in accordance with conventional optical industry practice. This allows the lens element to have more curvature thereto befitting use of the lens by the eye. The sphere would be more spherical and the cylinder would be toroidal.

Along the edge of the fifth and sixth surfaces 87, 89 is a lip 91 that projects somewhat axially and radially outward from the fifth surface 87. The lip 91 couples to the ring member 57. In the preferred embodiment, the lip 91 and the ring member 57 are coupled together by threads 93 (Fig. 2). This has an advantage in that the axis of the cylindrical sixth surface 89 can be rotated to adjust for the wearer's astigmatism. In addition, the prescription lens can be removed without disturbing the seals 61, 65 around the fluid cell 15. Alternatively, the lip 91 can be coupled to the ring 57B by adhesive (see Fig. 4). This has an advantage of allowing the ring and the circumference of the prescription lens 17 to be noncircular. As still another alternative, the ring 57C can be integral to the prescription lens 17 (Fig. 5).



1 The prescription lens 17 is also made of a transparent material such as  
2 glass or plastic. The prescription lens can be ground and polished in  
3 accordance with conventional techniques, or it can be molded, or a  
4 combination of both processes.

5 Fig. 6 shows the prescription lens 17A in accordance with another  
6 embodiment. The prescription lens 17A is a conventional and commercially  
7 available ophthalmic lens, such as the type used in conventional frame  
8 eyewear. The lens 17A is made as in accordance with conventional practice.  
9 Then, the edge 92 is ground and placed into an adapter 94. An adhesive can  
10 be used to retain the lens 17A in the adapter. The adapter 94 is in turn  
11 coupled to the ring 57A by threads 96. Thus, the prescription lens 17A can  
12 be rotated to orient the cylinder.

13 The use of an adapter, as shown in Fig. 6, has the advantage of being  
14 able to use a relatively inexpensive prescription lens, instead of a customized  
15 lens.

16 The lens arrangement 11 is assembled as follows (with reference to  
17 Figs. 1 and 2). The membrane 21 is placed into the base 19 so that the edge  
18 portion 49 of the membrane contacts the base projection 43. The ring  
19 member 57 is then coupled to the base 19. The seal 61 contacts the edge  
20 portion 49 of the membrane 21, to form a fluid tight seal. In the  
21 embodiment shown in Fig. 2, the ring 57 is threaded into the lip 41. Fluid  
22 23 is injected into the fluid cell 15 through the inlet passage 67 while the air  
23 inside of the cell is allowed to escape through the outlet passage 69. Fluid is  
24 injected until the fluid cell is completely full of fluid. The prescription lens  
25 17 is coupled to the ring member 57. The edge of the base 19 is ground,

1 beveled and fit into the frame 13. Grinding and beveling of the edge of the  
2 base can occur before attaching the membrane and prescription lens.

3 The wearer's eye is located closest to the sixth surface 89 of the  
4 prescription lens 17. Thus, the prescription lens is interposed between the  
5 fluid cell 15 and the eye.

6 If the prescription lens 17 has a cylindrical surface, then the lens is  
7 rotated to the proper orientation. If the prescription lens changes, then the  
8 old prescription lens is removed and the new one is coupled to the ring (for  
9 the configurations of Figs. 1-4 and 6) or to the lip 41 of the base (for the  
10 configuration of Fig. 5). Thus, the wearer is able to use the existing frame,  
11 base, etc. Also, the prescription lens need not be edge ground and beveled to  
12 fit within the frame, resulting in a cost savings.

13 The corrective power of the lens arrangement 11, which includes the  
14 fixed prescription lens 17, can be modified with the fluid cell. Adding or  
15 removing fluid 23 from the cell produces a change in the overall corrective  
16 power of the lens arrangement. Adding fluid to the fluid cell 15 forms a  
17 more positive lens of the fluid. The fluid lens is formed by the base second  
18 surface 35 and the membrane third surface 51. The fluid lens thus combines  
19 with the prescription lens 17 to provide more corrective power. Removing  
20 fluid from the fluid cell forms a more negative lens of the fluid. The fluid  
21 lens thus combines with the prescription lens to provide less corrective  
22 power. Thus, the fluid cell provides variable focus over a wide range of  
23 diopters to the lens arrangement.

1 The membrane 21 can flex from its neutral position either toward or  
2 away from the lens 17. Flexing toward the lens 17 produces a more positive  
3 lens, while flexing away from the lens 17 produces a more negative lens.

4 It is preferable, although not necessary to provide a null corrective  
5 power for the fluid cell, and that this null corrective power be obtained when  
6 the membrane is in a neutral position. The membrane 21 is in a neutral  
7 position when the pressures on both of its surfaces is equal, as shown in Fig.  
8 1. A loss of controlled pressure in the fluid cell results in the membrane  
9 occupying the neutral position.

10 A null corrective power is obtained by considering: the curvature of  
11 the first and second surfaces of the base 19, the separation between the base  
12 and the membrane 21, the thickness of the membrane, and the respective  
13 indices of refraction of the base, fluid and membrane. For example, the  
14 curvature of the first surface 33 of the base 19, the thickness of the  
15 membrane 21, the indices of refraction of the base 19, the membrane 21 and  
16 the fluid could be chosen arbitrarily, and then the curvature of the second  
17 surface 35 of the base and the separation can be determined. The curvature  
18 of the second surface 35 of the base is selected depending on the curvatures  
19 of the first surface 33 of the base and the membrane third and fourth surfaces  
20 51, 53 so as to provide a null corrective power. The provision of a null  
21 corrective power is a safety feature. If the fluid cell loses pressure, then the  
22 wearer can at least look through the lens arrangement with the original  
23 corrective power of the prescription lens. If the fluid is drained from the  
24 cell, the person will be looking through the base 19, which is a negative lens,

1 focusing on objects at a greater distance. This is a fail safe mode, as losing  
2 fluid and focusing on near objects could present problems to the wearer.

3 The lens arrangement 11 only has two exposed surfaces, namely the  
4 base first surface 33 and the prescription lens sixth surface 89. The other  
5 surfaces are protected from dust, debris, oils and greases. The two exposed  
6 surfaces can be easily cleaned.

7 The lens arrangement can be disassembled for maintenance. Also, any  
8 of the first through sixth surfaces 33, 35, 51, 53, 87, 89 can be used for  
9 coatings, shadings and polarizing.

10 The pump and controller mechanism is shown in Fig. 8. The pump  
11 mechanism is used to introduce or withdraw fluid from a fluid cell 15.

12 For a single fluid cell, the pump and controller mechanism includes  
13 the pump 25, a motor 97, the controller 27, and a battery 99. (In Fig. 8, the  
14 components are shown with a number followed by L or R, for left or right.)  
15 In a preferred embodiment involving eyewear, there is a left lens  
16 arrangement with a left fluid cell 15L and a right lens arrangement with a  
17 right fluid cell 15R. One way to provide independent operation of the two  
18 fluid cells relative to each other is shown in Fig. 8. For the left fluid cell  
19 15L, there is a left pump 25L, a left reservoir 95L, a left motor 97L and a  
20 left controller 27L, while for the right fluid cell 15R, there is a right pump  
21 25R, a right reservoir 95R, a right motor 97R and a right controller 27R.  
22 The controllers 27L, 27R each have a battery 99L, 99R.

23 Each pump 25L, 25R controls the flow of fluid between the respective  
24 reservoirs and the respective fluid cell. In the preferred embodiment, the  
25 pumps are positive displacement pumps that each operate on a flexible

1 tubing between the respective reservoir 95L, 95R and the respective fluid  
2 cell 15L, 15R. Each pump is operated by a respective motor 97L. Each  
3 motor is in turn operated by a respective controller 27L, 27R. Other types of  
4 pumps can be utilized.

5 An example of a positive displacement pump is shown and discussed  
6 in Floyd, U.S. Patent No. 5,684,637. When the pump is operated by the  
7 motor, rollers press on flexible tubing, which flexible tubing extends from  
8 the reservoir to the tube 73 of the fluid cell. If the rollers move toward the  
9 fluid cell, fluid is pumped out of the reservoir and into the fluid cell. If the  
10 rollers move toward the reservoir, fluid is pumped out of the fluid cell and  
11 into the reservoir. The reservoir stores a quantity of fluid. The connection  
12 between the motor and pump prevents backdriving of the pump when the  
13 motor is not driving.

14 In the pumping scheme described above, one passage to the fluid cell  
15 can carry fluid to and from the cell. The other passage carries gases and  
16 fluid from the cell. It is possible to operate with one passage but when doing  
17 so, gases are not removed from the cell. The connection between the pump  
18 and cells involves check valves 77 (see Fig. 1) to determine the direction of  
19 flow.

20 Each controller 27 includes a microprocessor (see Fig. 8).  
21 Alternatively, a mask ROM version of a microprocessor can be used, in  
22 order to permit the use of lower supply voltage and a reduced battery  
23 requirement. Each controller 27 also includes an oscillator for timing  
24 signals, an output connected to the respective motor 97, and an input/output

channel 115 connected to the other controller. The input/output channel 115 is a two wire channel.

In addition, each controller has five switches 101, 103, 105, 107, 109 connected thereto, which switches provide inputs. The operator, or eyewear wearer, utilizes these switches to adjust the fluid cells. The switches control the direction of the respective motor rotation (clockwise or counterclockwise), the duration of the motor rotation when energized and the speed that the motor rotates. Furthermore, when one controller is commanded to operate both sides, it operates its own side and sends a signal to the other controller to operate the other side. When a controller is commanded to operate only its own side, it does not send a signal to the other controller.

The switches are as follows: an increase switch 101, a decrease switch 103, a mode switch 107, and a resolution switch 109.

The switches 101, 103, 107 and 109 are normally open momentary closure switches. Thus, the switches are pressed to closed.

The increase and decrease switches 101, 103 control the direction that the motor 97 rotates. One switch, when closed, causes the motor to rotate clockwise. The other switch, when closed, causes the motor to rotate counterclockwise. For example, the increase switch 101 causes the motor 97 to rotate clockwise, wherein fluid is pumped into the fluid cell. This causes the membrane 21 to flex toward the prescription lens 17. Conversely, the decrease switch 103 causes the motor to rotate counterclockwise, wherein fluid is pumped out of the fluid cell. This causes the membrane 21 to flex toward the base 19.

1 When either the increase or the decrease switches 101, 103 are closed,  
2 the motor rotates in the specified direction for a predetermined amount of  
3 time. Thus, for each closure operation of the increase and decrease switches  
4 101, 103, a predetermined amount of fluid is pumped into or out of the fluid  
5 cell.

6 The predetermined run time for the motor is:

7

$$8 \quad \text{Run Time} = \text{Pulses} * N,$$

9

10 where N is the number of pulses. Each pulse has a duration of, for example,  
11 128 milliseconds.

12 The run time is changed by pressing the resolution switch 109. Then,  
13 the resolution is increased or decreased by pressing the increase switch 101  
14 or the decrease switch 103. Each operation of a switch 101, 103 changes N  
15 by an increment.

16 To maintain a resolution setting, the resolution switch 109 is pressed  
17 again. Then, use of the increase and decrease switches 101, 103 will move  
18 fluid in and out of the cell.

19 The eyewear can be configured to have the left pump and controller  
20 mechanism in the left earpiece and the right pump and controller mechanism  
21 in the right earpiece. Many people have a dominant hand, either being right  
22 or left handed. The present invention allows the wearer to control both fluid  
23 cells from a single side.

24 To accomplish such dual control, the mode switch 107 is used.  
25 Pressing the mode switch toggles between two modes, namely single and

1 dual. In the single mode, the controller operates only its respective fluid cell  
2 pump. In the dual mode, the controller operates its respective fluid cell pump  
3 and signals the other controller which controls the pump for the other fluid  
4 cell. For example, in the dual mode, the right controller 27R can be used to  
5 pump fluid in or out of both of the right and left fluid cells 15R, 15L. The  
6 signals from the right controller are passed over the input/output channel 115  
7 to the left controller. The right and left pumps 25R, 25L are operated in  
8 identical manners. To change modes, the mode switch 107 is pressed.

9 Although the lens arrangement has been described as having the base  
10 19 incorporated into a separate frame 13, the base could form the frame in an  
11 integral part.

12 Fig. 9 shows a lens arrangement 11 S in accordance with another  
13 embodiment. The lens arrangement is designed to form a significant portion  
14 of a comfortable frame. One side forms a smooth curved surface 121 for  
15 bearing on the side of a human's nose. Specifically, the base lip 41 S, the  
16 ring 57S and the adapter 94S all form the smooth surface 121. In the  
17 preferred embodiment, the smooth surface may be spherical or toroidal.

18 The lens arrangement 11 S of Fig. 9 is paired with a similar, but  
19 opposite lens arrangement to form a complete pair of eyewear.

20 The foregoing disclosure and the showings made in the drawings are  
21 merely illustrative of the principles of this invention and are not to be  
22 interpreted in a limiting sense.